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DESCRIPTION

FRICTION ROLLER TRANSMISSION

Technical Field

The present invention relates to a friction roller transmission for transmitting torque while changing speed by means of a friction roller.

Background Art

In Japanese Patent Application Laid-Open Nos. 2002-349653 and 2003-28251 filed and laid open prior to this patent application, there is disclosed a friction roller transmission characterized in that:

a first roller and a second roller are disposed on two parallel shafts that are separated from each other in such a way that the rollers are not in contact with each other, the shafts being at the center of the respective rollers;

a third roller and a fourth roller that are in contact with both the first and the second rollers are disposed between the first roller and the second roller and on opposite sides with respect to the line connecting the center of the first roller and the center of the second roller; and

the angle formed by the tangential line of the

first roller and the third roller and the tangential line of the second roller and the third roller and the angle formed by the tangential line of the first roller and the fourth roller and the tangential line of the second roller and the fourth roller are designed to be smaller than or equal to twice the respective angles of friction that are determined from the coefficients of friction between the respective rollers.

With the above features, it is possible to constitute a transmission path from the first roller to the third roller and then to the second roller, and another transmission path from the first roller to the fourth roller and then to the second roller, thereby allowing both the forward and backward rotations in a backlash-free frictional roller transmission. It is also possible to minimize an increase in the working torque by generating a roller pressing power in accordance with the transmitted torque, whereby the efficiency can be improved, particularly in the low transmitted torque range. In addition, since the rollers for power transmission are respectively provided for the rotation directions in such a way as to be in contact to the rollers, torque transmission can be made possible without delay and without generating a slapping sound even when the direction of rotation is reversed.

A more specific description will be made in the following under an assumption that the first roller is the input side roller.

When the first roller is rotated clockwise (in the CW direction), since the tangential line of the third roller and the first roller and the tangential line of the third roller and the second roller form an angle smaller than or equal to twice the friction angle, each contact angle is not larger than the friction angle. Accordingly, relative slippage of the third roller and the first roller does not occur at their contact portion. Thus, a rotational force of the counterclockwise direction (in the CCW direction) is transmitted to the third roller by this tangential force in the direction in which the third roller is brought closer to the first roller.

At the contact portion between the third roller and the second roller also, since the tangential line of the third roller and the first roller and the tangential line of the third roller and the second roller form an angle smaller than or equal to twice the friction angle, each contact angle is not larger than the friction angle. Accordingly, relative slippage of the third roller and the second roller does not occur at their contact portion. Thus, a tangential force acts on the second roller from the third roller, so that the second roller receives a

rotational force in the CW rotation direction. As the reaction, the third roller receives a tangential force in the opposite direction. This tangential force is in such a direction that the third roller is brought closer to the second roller.

The tangential forces acting on the third roller is a force biasing the third roller toward the first and the second rollers, and therefore, a pressing force corresponding to the tangential force transmitted or the torque can be obtained. The operation of the fourth roller is the same as the operation of the third roller except for the direction of rotation, and the description thereof will be omitted.

An improvement of the technology disclosed in the aforementioned Japanese Patent Application Laid-Open No. 2003-28251 is disclosed in Japanese Patent Application Laid-Open No. 2003-247617 that was filed by the applicant of the present patent application on February 21, 2002, which was prior to the priority date of the present patent application (that is, April 8, 2003) and laid open on September 5, 2003, the inventorship of which is the same as the inventorship of the present patent application). In this improvement, a setting member for setting the distance between two support plates that couples bearings that rotatably support the first and the

second rollers at both ends of these rollers to a predetermined dimension. The setting member is a cylindrical spacer through which a bolt on which a backup rolling bearing is attached is inserted or a cylindrical spacer through which a bolt that secures the two support plate is inserted.

The aforementioned backup rolling bearing is provided in contact with the third or fourth roller so as to restrict displacement of the third or the fourth roller to a predetermined amount. The backup rolling bearing is adapted to restrict displacement of the third roller or the fourth roller to a predetermined amount to prevent getting-over of the third or fourth roller and to prevent transmission of torques larger than a predetermined torque.

As per the above, the distance between the two support plates can be set to a predetermined dimension by the setting member in the form of the cylindrical spacer. However, the volume of the interior space in the friction roller transmission is large, and traction grease is scattered upon rotation of the rollers. Thus, A large amount of traction grease will be consumed.

Traction oil that constitutes the base oil of traction grease has a very high evaporability, and it evaporates to cause a saturated state in the interior space of the friction roller transmission. This has

been one of the causes of deterioration of traction grease.

Disclosure of the Invention

The present invention has been made in view of the above described circumstances, and has as an object to provide a friction roller transmission in which scattering of traction grease is prevented, the consumption amount and the evaporation amount of traction grease is reduced, and thereby the life of traction grease can be prolonged.

To achieve the above object, according to the present invention, there is provided a friction roller transmission comprising:

a first roller and a second roller disposed on two parallel shafts that are separated from each other in such a way that the rollers are not in contact with each other, the shafts being at the center of the first and the second rollers respectively;

a third roller and a fourth roller that are in contact with both the first and the second rollers disposed between said first roller and said second roller, the third roller and the fourth roller being opposite to a line connecting the center of the first roller and the center of the second roller; and

backup bearings that are in contact with said

third and said fourth rollers respectively to restrict displacement amount of said third roller and said fourth roller;

characterized by two support plates disposed on both axial sides of said first roller and said second roller and having bearings for rotatably supporting the first and the second rollers respectively; and

a setting member for setting the distance between said two support plates to a predetermined dimension.

As per the above, the friction roller transmission according to the present invention is provided with a setting member that sets the distance between the two support plate to a predetermined dimension, and the volume of the interior space of the friction roller transmission is designed to be small. Therefore, it is possible to prevent scattering of traction grease, to reduce the consumption amount and the evaporation amount of traction grease, and to thereby prolong the life of traction grease.

Preferably, said setting member may be a plate-like spacer disposed between said two support plates.

Brief Description of the Drawings

Fig. 1A is a side view of a friction roller transmission that constitutes a basic structure

according to the present invention.

Fig. 1B is a schematic perspective view of the friction roller transmission shown in Fig. 1A.

Fig. 2A is a side view of the friction roller transmission that constitutes the basic structure according to the present invention, showing a transmission path from the first roller to the fourth roller and then to the second roller.

Fig. 2B is a side view of the same kind showing a transmission path from the first roller to the third roller and then to the second roller.

In Figs. 3A to 3C that show a friction roller transmission according to an embodiment of the present invention, Fig. 3A is a partly cut-away front view, Fig. 3B is a cross sectional view taken along line b-b in Fig. 3A, and Fig. 3C is a cross sectional view taken along line c-c in Fig. 3B.

Fig. 4 is an exploded cross sectional view of the friction roller transmission shown in Figs. 3A to 3C.

Fig. 5 is an exploded perspective view of the friction roller transmission shown in Figs. 3A to 3C.

Embodiment of the Invention

In the following, a friction roller transmission according to a preferred embodiment of the present invention will be described with reference to the

drawings.

(Basic Structure)

Fig. 1A is a side view of a friction roller transmission that constitutes the basic structure according to the present invention. Fig. 1B is a schematic perspective view of the friction roller transmission shown in Fig. 1A. Fig. 2A is a side view of the friction roller transmission that constitutes the basic structure according to the present invention, illustrating a transmission path from the first roller to the fourth roller and then to the second roller. Fig. 2B is a side view of the same kind illustrating a transmission path from the first roller to the third roller and then to the second roller.

In this basic structure of the friction roller transmission as shown in Figs. 1A, 1B, 2A and 2B,

a first roller 1 and a second roller 2 are disposed on two parallel shafts that are separated from each other in such a way that the rollers are not in contact with each other, the shafts being at the center of the respective rollers;

a third roller 3 and a fourth roller 4 that are in contact with both the first roller 1 and the second roller 2 are disposed between said first roller 1 and said second roller 2 and on opposite sides with respect to the line connecting the center

of the first roller 1 and the center of the second roller 2; and

an angle formed by a tangential line of the first roller 1 and the third roller 3 and a tangential line of the second roller 2 and the third roller 3 and an angle formed by a tangential line of the first roller 1 and the fourth roller 4 and a tangential line of the second roller 2 and the fourth roller 4 are designed to be smaller than or equal to twice the respective angles of friction that are determined from the coefficients of friction between the respective rollers, the frictional portions thereof being located outside the rollers.

In other words, letting P1 to P4 be the centers of the respective rollers, the rollers are designed in such a way that the sum of the angle formed by the line P1P2 and the line P1P3 (α_1: ∠P2P1P3) and the angle formed by the line P1P2 and the line P2P3 (α_2: ∠P1P2P3) and the sum of the angle formed by the line P1P2 and the line P1P4 (α_3: ∠P2P1P4) and the angle formed by the line P1P2 and the line P2P4 (α_4: ∠P1P2P4) are smaller than or equal to twice the friction angle ($\theta = \tan^{-1}\mu$) as formulated below.

$$\alpha_1 + \alpha_2 \leqq 2\theta$$

$$\alpha_3 + \alpha_4 \leqq 2\theta$$

In cases where the above-described arrangement is adopted, since the friction angle is small, the

third roller 3 and the fourth roller 4 are necessarily disposed in a overlapping manner along the axial direction.

By adopting the above-described structure, a pressing force can be created in accordance with the transmitted torque. Therefore, it is not necessary to apply forces required for frictional transmission, namely forces for pressing the third and the fourth rollers 3 and 4 against the first and the second rollers 1 and 2 respectively. However, it is preferable that weak pressing forces be applied for retaining the initial contact state when the roller is not rotating. Although each roller is composed of one roller, it may be composed of a plurality of rollers.

In the following, the operation of the structure will be described under the assumption that the first roller 1 is the input side roller.

As shown in Figs. 1B and 2B, when the first roller 1 is rotated clockwise (in the CW direction), since the angle formed by the tangential line of the third roller 3 and the first roller 1 and the tangential line of the third roller 3 and the second roller 2 is smaller than or equal to twice the friction angle, the respective contact angles are smaller than or equal to the friction angle. Accordingly, relative slippage between the third

roller 3 and the first roller 1 does not occur at their contact portion, and the third roller 3 receives a tangential force from the first roller 1. This tangential force is in such a direction that the third roller 3 is brought closer to the first roller 1, and the third roller 3 receives a counterclockwise force (in the CCW direction) by this tangential force.

In the contact portion between the third roller 3 and the second roller 2 also, since the tangential line of the third roller 3 and the first roller 1 and the tangential line of the third roller 3 and the second roller 2 form an angle smaller than or equal to the friction angle, the respective contact angles are smaller than or equal to the friction angle. Therefore, relative slippage between the third roller 3 and the second roller 2 does not occur at their contact portion. Accordingly, the second roller 2 receives a tangential force from the third roller 3 and receives a rotational force in the CW direction. As a reaction thereto, a tangential force in the opposite acts on the third roller 3. This tangential force is in such a direction that the third roller 3 is brought closer to the second roller 2.

As per the above, the tangential forces acting on the third roller 3 are in such a direction that the third roller 3 is pressed against the first

roller 1 and the second roller 2. Accordingly, a pressing force is created in accordance with the transmitted tangential force or torque.

In this case, as shown in Fig. 2A, slippage does not occur in the contact portions of the fourth roller 4. Accordingly, the fourth roller 4 receives tangential forces from the first and the second rollers 1 and 2. However, the forces are in such a direction that the fourth roller 4 is brought away from the first and the second rollers 1 and 2, and the fourth roller 4 is only rotating while in contact with the first roller 1 and the second roller 2.

When the rotation of the first roller 1 is reversed and it rotates in the CCW direction as shown in Figs. 1B and 2A, the operation of the fourth roller 4 and the operation of the third roller 3 are switched to each other. In this case, since the fourth roller 4 has been already in contact with the first roller 1 and the second roller 2, the direction of power transmission can be changed smoothly when the direction of rotation is changed.

What is required to enable torque transmission is that each of the third and the fourth rollers 3 and 4 are in contact with the first and the second rollers 1 and 2. To retain the contact state, weak pressing forces for pressing the third and the fourth rollers 3 and 4 against the first and the second

rollers 1 and 2 may be applied.

As per the above, according to this basic structure, it is possible to constitute a transmission path from the first roller 1 to the third roller 3 and then to the second roller 2, and a transmission path from the first roller 1 to the fourth roller 4 and then to the second roller 2 to make forward and backward rotation possible in a backlash-free friction roller transmission (speed-reduction transmission). In addition, since a roller pressing force in accordance with the transmitted torque is created, it is possible to minimize an increase in the working torque. Particularly, it is possible to improve efficiency in the transmission torque range. Moreover, since the rollers that are always in contact are provided for transmitting power in respective rotational directions, torque transmission can be realized without delay and without generating a slapping sound even upon reversal of the rotation direction.

(Embodiment of the Present Invention)

Figs. 3A to 3C show a friction roller transmission (speed-reduction transmission) according to an embodiment of the present invention. Fig. 3A is a partly cut-away front view, Fig. 3B is a cross sectional view taken along line b-b in Fig. 3A, and

Fig. 3C is a cross sectional view taken along line c-c in Fig. 3B.

Fig. 4 is an exploded cross sectional view of the friction roller transmission (speed-reduction transmission) shown in Figs. 3A to 3C. Fig. 5 is an exploded perspective view of the friction roller transmission (speed-reduction transmission) shown in Figs. 3A to 3C.

This embodiment embodies the above-described basic structure, and the arrangement of the first to the fourth rollers 1 to 4, the contact angles and the friction angle are designed to be the same as those in the basic structure.

As shown in Fig. 3A to 3C and Fig. 5, a pair of support plates 11a, 11b are disposed on both sides of a plate-like spacer 10. A plurality of bolts 12 passing through one of the support plates 11a and the plate-like spacer 10 are screwed into screw holes on the other support plate 11b thereby assembling the plate-like spacer 10 and the two support plates 11a, 11b.

Between the plate-like spacer 10 and the pair of support plates 11a, 11b, a pair of ring-shaped sealing members 13, 13 are interposed. The plate-like spacer 10 is made of a light-weight material such as an aluminum alloy and may be formed by casting such as die casting.

The two support plates 11a and 11b have the same thickness and the same shape. The support plates 11a and 11b respectively have holes for supporting a pair of bearings 14, 14 that rotatably support the shaft 1a of the first roller 1 and holes for supporting a pair of bearings 15 and 15 that rotatably support the shaft 2a, 2a of the second roller 2. The support plates 11a, 11b are made of a material having a coefficient of linear expansion substantially the same as that of the third and the fourth rollers 3, 4.

In this embodiment, the shaft 1a of the first roller 1 is integral with the input shaft a, and the shaft 2a of the second roller 2 is integral with the output shaft b. Thus, this embodiment constitutes a speed-reduction transmission.

Surfaces of the support plates 11a, 11b are used as sliding surfaces for the third and the fourth rollers 3, 4. In the case of conventional integral type housings, the bottom face of an opening for allowing insertion of the third and the fourth rollers 3, 4 serves as a sliding surface, and therefore, it is difficult to apply finish processing thereto. In contrast, in this embodiment, the two support plates 11a, 11b have a simple plate-like shape. Accordingly, finish processing of the sliding surfaces can be easily carried out. Alternatively, the support plates 11a, 11b can be punched out using

a press molding process or the like to eliminate the finish processing itself. In addition, they may be the same parts that are opposed to each other, a cost reduction can be achieved.

The third and the fourth rollers 3, 4 are held by two holders 20, 20 with an offset. Each holder 20 is composed of a flange portion 21 having a nearly semicircular cross section and a shaft portion 22. The respective flange portions 21, 21 and the shaft portions 22, 22 of the two holders 20, 20 are offset from each other by a predetermined distance. The third and the fourth rollers 3, 4 are rotatably supported on the shaft portions 22, 22 of the holders 20, 20 respectively by means of the bearings 23, 23.

Backup rollers 30, 30 that are in contact with the third and the fourth rollers 3, 4 respectively are provided to restrict displacement the third and the fourth rollers 3, 4 to a predetermined amount. Each backup roller 30 is, for example, a rolling bearing with an outer ring serving as the contact surface.

In this embodiment, displacement of the third and the fourth rollers 3, 4 is restricted to the predetermined amount by the backup rollers 30, 30 in the form of the backup rolling bearings to avoid getting-over of the third and the fourth rollers 3, 4 and to prevent transmission of torques larger than a

predetermined torque.

As shown in Figs. 3A-3C and 5, the plate-like spacer 10 mentioned above is hollowed out to have a continuous space composed of a basically cylindrical space Sa for housing only the first roller 1, a basically cylindrical space Sb for housing only the second roller 2, a basically cylindrical space Sc for housing only the third and the fourth rollers 3, 4 and basically cylindrical spaces Sd for housing only the backup rolling bearings 30. The spaces Sd for housing the rolling bearings 30 are spaces having a bottom that open on opposite surfaces of the spacer 10 at symmetrical positions to back up the third and the fourth rollers 3, 4.

As per the above, in this embodiment, the plate-like spacer 10 is disposed between the pair of support plates 11a, 11b, so that the support plates 11a, 11b are fixed with a predetermined distance therebetween. By increasing the precision of the thickness of the plate-like spacer 10, it is possible to fix the distance between the pair of support plates 11a, 11b with a higher degree of accuracy.

In addition, since the aforementioned spaces Sa to Sd are formed continuously in the interior of the plate-like spacer 10, it is possible to reduce the volume of the interior space of the friction roller transmission as much as possible, and it is possible

to prevent traction grease from scattering, reduce the consumption amount and the evaporation amount of traction grease, and lengthen the life of traction grease.

In the inner rings of the respective backup rolling bearings 30, mounting bolts 31 are fitted and fixed. The mounting bolts 31 are secured to the pair of support plates 11a and 11b respectively. Each mounting bolt 31 has a head portion 31a to be fitted into the inner ring of the corresponding backup rolling bearing 30 and a shaft portion 31b having male threads formed thereon that are coaxial with each other. When the mounting bolt is attached, the male threads of the shaft portion 31b are screwed into a nut 32.

The present invention is not limited to the embodiment described in the foregoing, but various modifications may be made thereon.

As described in the foregoing, the friction roller transmission according to the present invention is provided with a setting member that sets the distance between the two support plate to a predetermined dimension, and the volume of the interior space of the friction roller transmission is designed to be small. Therefore, it is possible to prevent scattering of traction grease, to reduce the consumption amount and the evaporation amount of

traction grease, and to thereby prolong the life of traction grease.